SYSTEM AND METHOD FOR CDMA CHANNEL ESTIMATION

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates generally to cellular telephone communications, and more particularly to a system and method for mobile stations to use the timing information derived from the perch channel of an asynchronously transmitting base station to demodulate a traffic channel message.

Spread spectrum communication techniques allow communicating users to operate in noisy radio frequency (RF) spectrums, and are especially effective against narrow-band interferers. Spread spectrum communications can be effected at relatively low power spectral densities, and multiple users can share the same frequency spectrum. Further, receivers can be designed to protect against multipath. These system characteristics encouraged early development of the technology by the military.

Common forms of spread spectrum systems include chirp, frequency hopping, and direct sequence or pseudonoise (PN). The chirp system transmits an impulse signal in the time domain that is spread monotonically in the frequency domain. A receiver converts the spread frequency signal back into an impulse signal. These frequency-spread impulse signals have applications in radar, for the pulse position modulation of information, or both, such as the R^3 transponder developed by General Dynamics, Electronics Division in the 1970s. Frequency hopping systems communicate by synchronizing users to simultaneously change the communication frequency.

Direct Sequence systems spread a digital stream of information, typically in a quadriphase modulation format, with a PN code generator, to phase shift key modulate a carrier signal. The pseudonoise sequence of the PN code generator is periodic, and the spread signal can be despread in a receiver with a matching PN code. Direct Sequence systems have excellent immunity to noise. The PN codes used typically permit a large number of users to share the spectrum, with a minimum of correlation between the user's PN codes. However, Direct Sequence system require large RF bandwidths and long acquisition times.

The IS-95 standard defines key features of the so-called second generation code division multiple access (CDMA) communication system, a type of Direct Sequence spread spectrum modulation. To help solve the problem of long acquisition time, the IS-95 signal uses a pilot channel. Each base station transmits a pilot channel message spread with PN codes known to all the mobile stations. The PN code is made up a series of phase shifted binary symbols called chips. The PN period is 32,768 chips and the PN chip rate is 1.2288 Megahertz (Mhz). The digital stream of information that is spread by the PN code is also known to the mobile stations. Because there is no ambiguity in the demodulated message, the timing characteristics of the PN code, down to the chip phase, as well as the QPSK modulation phase are known to the mobile station receiver.

The IS-95 system communicates information from the base station to the mobile stations through a series of traffic channels. These traffic channels are transmit and receive information, i.e. digitized audio signals, spread with a traffic channel PN code, unique to each mobile station. Using this precise timing and phase information derived from the pilot channel, the mobile station is able to acquire a setup channel, and eventually, the overall System Time. With this System Time, the mobile station is able to differentiate between base stations and synchronize the demodulation circuitry with sufficient accuracy to recover the received traffic channel message.

A third generation, wideband CDMA (W-CDMA) system is in development as described in "Wideband-CDMA Radio Control Techniques for Third Generation Mobile Communication Systems", written by one et al., IEEE 47^{th} Vehicular Technology Conference Proceedings, May 1997, that may have global applications. Instead of a pilot channel, the W-CDMA system has a broadcast, or perch channel. Each timeslot, or slot of the broadcast channel consists of a series of time multiplexed symbols. A long code masked, or special timing symbol segment uses just a short code to spread one symbol of known information. This segment allows a mobile station to acquire system timing information immediately after turn-on. The pilot, or reference symbols are similar to the IS-95 pilot channel. In one proposal, 4 reference symbols, with each symbol being 2 bits, are spread with a long code and a short code. The reference symbol information and the short code are known by the mobile stations. The long code is unique to each base station, so that timing information is refined, once the long code is known (the base station is identified). Therefore, according to some proposals, 5 symbols in the slot would be dedicated to the mobile station acquiring timing information. Further, both the long and short codes spread 5 symbols of data during each slot. Since information is not predetermined for the data symbols, precise timing information cannot be accurately recovered, as with the other two kinds of (timing) symbols. Other combinations of reference, special timing, and data symbols are also possible.

The W-CDMA system also includes several traffic channels to communicate information, such as a digitized voice or data. The traffic channel predominately includes information, but may also include a reference symbol segment. For example, at a data rate of 32 kilosymbols per second (ksps), a slot could include 4 pilot symbols and 16 information symbols. Precise timing information can be derived during the reference symbols segment of the traffic channel message, but not during the information segments.

The W-CDMA, or any spread spectrum system, operates best by minimizing the transmitted power of the users. Lower spectral power densities permit additional users to be added to the system, or an increase in the signal to noise ratio of received messages. Each mobile station is likely to receive more than one traffic channel from a base station, with each traffic channel being unique to a mobile station. That is, each base station is capable of transmitting hundreds of different traffic channels, the exact number is dependent on the traffic channel data rates. However, each base station transmits only a few, perhaps only one, broadcast channels that are used by all the receiving mobile stations. It is advantageous for the system that the base stations transmit the shared broadcast channels at a higher power level than the mobile station specific traffic channels. For this reason, the broadcast channel power is maintained at a relatively high level, while the traffic channel levels are continually monitored and adjusted to keep the transmitted power levels only as large as necessary to reasonably enable communication between the base station and the mobile.

Unlike the IS-95 system, the W-CDMA system does not use a master System Time to synchronize the base station transmissions. Each mobile station must independently acquire sufficient timing information regarding each base station to recover messages from that base station. The mobile station must simultaneously maintain timing information for multiple non-synchronously transmitting base stations.